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AUTOMATIC REGULATOR FOR ELECTRIC SYSTEMS

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Fig. 1.

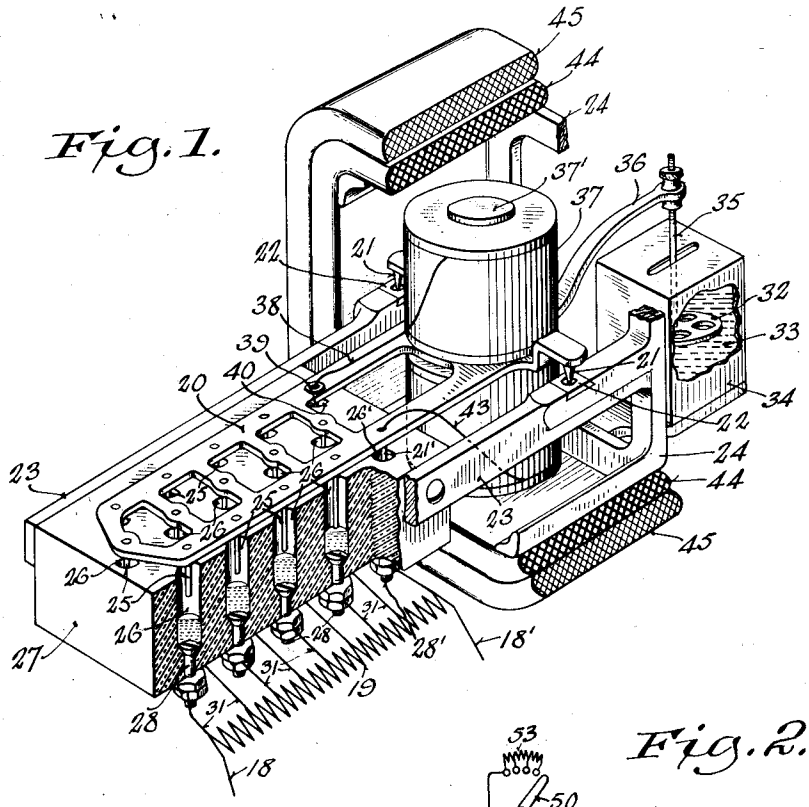
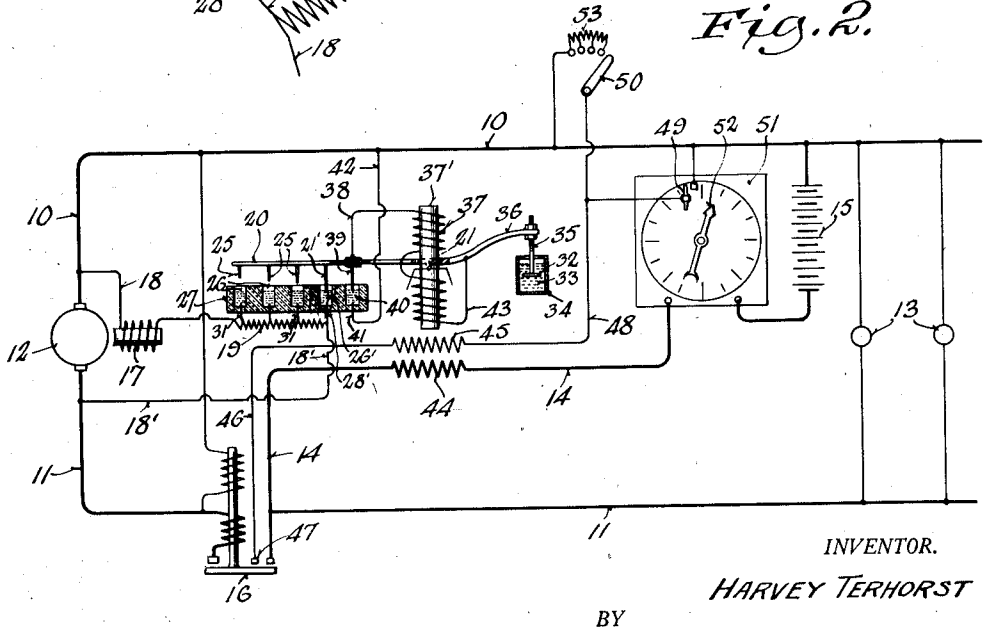


Fig. 2.



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AUTOMATIC REGULATOR FOR ELECTRIC SYSTEMS.

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This invention pertains to the regulation of generator battery electric lighting and power circuits.

One object of the present invention is the provision of an exceedingly sensitive regulator which will respond quickly and accurately to slight variations in the generator circuit to maintain the battery charging rate substantially constant.

Another object is the provision of novel means automatically operable when the battery has become fully charged to reduce the generator voltage to a potential best suited for feeding the work circuit.

Another object is the provision of means under the control of the operator for reducing the generator voltage to a potential best suited for feeding the work circuit before the battery is fully charged.

These and other objects and advantages will appear from the following description of an illustrative embodiment of the present invention.

In the accompanying drawings:

Figure 1 is a perspective view of a regulator constructed in accordance with the present invention, parts being broken away for clearness.

Figure 2 is a diagrammatic view of a generator battery lighting system illustrating a use to which the regulator of Figure 1 may be applied.

The system illustrated in Figure 2 comprises two main conductors 10 and 11 leading from the generator 12 to the lamps 13 and connected by a branch conductor 14 in which a storage battery 15 is connected. One of the main conductors 11 is provided with the usual automatic cut out switch 16 between the generator and battery. The generator is adapted to be driven at variable speed from the car axle, wind mill or other power source. The shunt field 17 of the generator is connected across the two conductors 10 and 11 through leads 18 and 18' and through variable resistance 19 controlled by a regulator preferably such as will now be described.

The regulator shown, particularly in Figure 1, comprises an arm 20 normally balanced in substantially horizontal position but free to swing about a substantially horizontal axis. The arm 20 is shown provided with a pair of fulcrum points 21 each resting upon a bearing block 22 of hard, preferably insulating, material, secured in a fixed horizontal rail 23 constituting a part of a substantially rectangular frame 24. The arm carries a series of contact points 25 in electrical contact therewith and each depending therefrom into one of a series of mercury cups 26 formed in a block 27 of insulating material. This block is rigidly supported by and between the fixed rails 23 and is provided in its base with a series of binding posts 28 each in electrical contact with the mercury in one of the cups 26. The several binding posts 28 are connected through leads 31 with the resistance 19 at successive intervals thereon.

The mercury in the several cups is at a uniform level and the several contact points 25 are of different graduated lengths so that, as the arm 20 is swung upwardly from its normal horizontal position, the points 25 are successively withdrawn out of contact with the mercury in the corresponding cups. The arrangement is such that when the arm is in its normal horizontal position with all the points 25 in electrical contact with the mercury in the corresponding cups, the resistance 19 is short-circuited out of the generator field circuit and generator voltage is at a maximum, but as the arm moves from horizontal position so as to withdraw the points 25 successively out of the bodies of mercury successive increments of the resistance 19 are returned to the field circuit to reduce the generator voltage.

It might be pointed out here that with all of the points 25 partially immersed in the mercury in the several cups, the arm 20 is partially supported by the buoyant effect of the mercury upon the points, but as the arm is swung upwardly this buoyant effect is reduced so that the torque required to swing the arm upwardly becomes greater as the arm swings upwardly. In order to insure a smooth action of the arm against the inertia effect thereof and of the parts carried thereby a dashpot of appropriate design is preferably provided. In this instance, the dashpot employed comprises a dasher 32 immersed in a body of liquid 33, preferably oil, contained in an appropriate chamber 34. The dasher is supported by a rod 35 extending through the top of the chamber and pivotally secured to a rear extension 36 of the arm 20.

The arm 20 carries a polarized magnet in the form of a coil 37 wrapped about a post 37' fixed in vertical position on the arm so

that the axis thereof is normal to and intersects the horizontal axis about which the arm rocks. This coil is connected across the generator circuit. One terminal thereof is connected through a lead 38 to a contact point 39 carried by the arm 20 and insulated therefrom. This contact point is in permanent contact with the mercury in a cup 40 formed in the block 27. The binding post 41 of the cup 40 is connected through a lead 42 with one of the main conductors 10. The other terminal of the coil is connected through a lead 43 with the arm 20 and through a contact point 21', mercury cup 26', binding post 28' and lead 18' to the other main conductor 11. It is understood, of course, that the point 21' is always in electrical contact with the mercury in cup 26'. By thus connecting the leads 38 and 43 to parts carried by the arm 20, rather than to fixed points in the system, movement of the arm is not hindered by the otherwise necessary flexing of the leads, and the arm, coil, and leads are removable as a unit from the rest of the mechanism.

The arm 20 is regulated and controlled by the coil 37 which reacts under the influence of the magnetic field which in turn responds to conditions in the main circuit. In the regulator shown, a coil 44 is wrapped about the main frame 24 with its axis normal to and intersecting both the axis of coil 37 and the horizontal axis about which the arm 20 swings. Coil 44 is connected in the branch conductor 14 in series with the battery 15 so as to respond to the current flow between the generator and battery. The arrangement is such that while the battery is being charged the magnet field set up by the current passing through coil 44 reacts upon the magnetic field of the coil 37 to maintain the coil 37 and consequently the arm 20 in a slightly tilted position. With every change in the battery charging rate there is a corresponding change in the strength of the field of the coil 44 which results in a variation in the position of the coil 37 and arm 20. Thus the amount of resistance in the shunt field of the generator is made to vary directly as the battery charging rate so that as the charging rate tends to increase above normal, generator voltage immediately decreases, and vice versa, with the result that the current flow to the battery is automatically maintained at a definite normal rate.

Since the effect of gravity on the arm 20 in any of its tilted positions varies directly as the cosine of the angle of inclination of the arm, and since the magnetic pull of coil 44 upon coil 37 varies directly as the cosine of the angle of inclination of the coil 37, and since these angles are always equal, it necessarily follows that the relative effectiveness of the force of gravity, tending to return the arm 20 to horizontal position, and of the magnetic pull between the coils 37 and 44, tending to tilt the arm, are substantially the same in all positions of the arm. The variations in the magnetic strength of coil 44 are thus balanced solely against the variations in the buoyant effect of the mercury upon the contact points 21. The arm 20 will thus respond to very slight changes in the current passing through coil 44. It will also be noted that the coil 44 is free from iron so that lag and hysteresis losses are avoided.

Another coil 45 is wrapped about coil 44 and similarly disposed relatively to the coil 37. This coil 45 is connected at one end through a lead 46 to a fixed contact 47 through which it is connected to the main conductor 11 when the cut-out switch 16 is closed. The other end of coil 45 is connectible to the other main conductor 10 through a lead 48 and either of two switches 49 or 50. Switch 49 is arranged to close automatically when the battery 15 has been fully charged and for this purpose is placed under the control of an appropriate device which responds to the condition of charge of the battery. In the system shown, this device is typified by an ampere-hour meter 51, connected in the branch conductor 14 in series with the battery and having a pointer 52 which when the battery is fully charged strikes and closes the switch 49. The other switch 50 is a manually operated switch ordinarily placed at a distance from the regulator. This switch is operable to close the shunt circuit through the coil 45 before the battery is fully charged and cooperates with a variable resistance 53 in series with the coil 45 by which the strength of the coil may be regulated.

The operation of the system will now be described. As the generator 12 comes up to speed the cut-out switch 16 automatically closes in the usual manner. Assuming that the battery 15 is not fully charged, current flows from the generator through the branch conductor 14, coil 44, and meter 51 to the battery to charge the battery. Under these conditions, coil 44 acting upon coil 37 controls the arm 20 of the regulator to maintain the charging current substantially constant as hereinabove described. When the battery has been fully charged, as indicated by the meter 51, the pointer 52 thereof strikes and closes the switch 49, thereby connecting the coil 45 across the generator circuit. The coil 45 thus excited exerts a magnetic pull upon the coil 37 causing a further tilting of the arm 20 so that an increased resistance is thrown into the generator field circuit to reduce generator voltage to such an extent as to cause the generator to float on the battery. The fact that the coil 37, as well as coil 45, is connected across the generator circuit and is hence responsive to fluctuations in generator voltage renders the regulator

exceedingly sensitive during this floating condition. Under this condition the coil 44 becomes practically inactive except that it responds to slight flow therethrough in one direction or another to maintain the floating condition.

In some instances, it has been found desirable to reduce the generator voltage before the battery is fully charged, as, for example, to taper off the battery charging rate as the battery approaches a fully charged condition. At such times the voltage necessary to maintain a normal charging rate is ordinarily excessive for the efficient operation of the work circuit. To reduce the generator voltage at such times, the switch 50 is closed so as to excite the coil 45. This obviously results in a further tilting action of the arm 20 to increase the field resistance 19 and decrease the generator voltage. By reducing the resistance 53 a further reduction in the generator voltage may be obtained. In this way the battery continues to be charged, but at a lower rate, while the generator voltage is reduced to that appropriate for operating the work circuit.

Various changes may be made in the embodiment of the invention hereinabove specifically described, without departing from or sacrificing any of the advantages of the invention as defined in the appended claims. The term "balanced member", as hereinafter employed, is intended to designate a member in a state of equilibrium freely rockable about an axis, either horizontal or otherwise, under the influence of a slight exciting force.

I claim:

1. In a regulator the combination of a variable resistance, a rockable member cooperating with said resistance to regulate the same, means structurally combined with said member to form a balanced unit and providing a magnetic field, and means providing a variable magnetic field disposed at an angle to said first named field and impressed thereon to control said unit to thereby regulate said resistance.

2. In a regulator the combination of means providing a variable magnetic field, magnetic means angularly disposed within said field and responsive to fluctuations therein, a member structurally combined with said magnetic means to form a balanced unit freely movable in response to said fluctuations, and a variable resistance controlled by said member.

3. In a regulator the combination of means providing a variable magnetic field, magnetic means having a field disposed within and substantially normal to said first named field, a member structurally combined with said magnetic means to form a balanced unit rockable about an axis substantially normal to the axes of said fields in response to fluctuations in said first named field, and a variable resistance controlled by said member.

4. In a regulator the combination of a variable resistance, a rockable member cooperating with said resistance to regulate the same, and means comprising two relatively movable elements providing angularly disposed relatively movable magnetic fields reacting to control said member, one of said elements being structurally combined with said member to form a unit balanced against the reactions between said fields.

5. In a regulator the combination of a variable resistance, a member rockable to vary said resistance, means providing a variable magnetic field, and magnetic means rockable in response to variations in said field, said magnetic means being structurally combined with said member to form a unit balanced against the reaction of said field on said magnetic means.

6. In a regulator the combination of a series of mercury cups, a variable resistance, a rockable member cooperating with said cups to regulate said resistance, and means comprising two relatively movable elements providing reacting magnetic fields for controlling said member, one of said elements being structurally combined to form a rockable unit balanced against the reactions between said fields.

7. In a regulator the combination of a series of mercury cups, a member having a series of contact points depending in said cups, respectively, said member being balanced for rocking action about a substantially horizontal axis and movable to withdraw said points successively from contact with the mercury in said cups, said member being partially supported by the buoyant effect of the mercury on said points, and means providing a pair of reacting magnetic fields for rocking said arm about the pivotal axis thereof to withdraw said points successively out of contact with the mercury in said cups.

8. In a regulator the combination of a resistance, a member rockable about a fixed axis, fluid contacts controlled by said member for regulating said resistance, means providing a magnetic field of varying intensity, and an element structurally combined with said member to form a balanced unit and providing a magnetic field angularly disposed within said first named field reacting to fluctuations therein to actuate said member.

9. In a regulator the combination of a resistance, a member mounted for free rocking action about a fixed axis, fluid contacts controlled by said member for regulating said resistance, a magnetic element fixed to said member adjacent said axis to form a balanced unit, and a fixed electro-magnetic

coil surrounding said element for actuating the same.

10. In a regulator the combination of a resistance, a member mounted for free rocking action about a fixed axis, fluid contacts controlled by said member for regulating said resistance, an element fixed to said member adjacent said axis to form a balanced unit and providing a magnetic field substantially normal thereto, and an electromagnetic coil surrounding said element and providing a magnetic field substantially normal to said axis and to said first named field and reacting on said first named field to control the position of said member.

In witness whereof, I hereunto subscribe my name this 5th day of April, 1924.

HARVEY TERHORST.